

Claims:

1. A system for forwarding data packets to a mobile terminal comprising:

5 a radio access network comprising at least one externally connected gateway node, a plurality of packet routers, and a plurality of radio access nodes each having a respective coverage area and each capable of establishing a wireless communications link with mobile terminals within the respective coverage area, each packet router and each radio access node having a respective network address, each packet router associating a next-hop forwarding entry with each of the radio access nodes;

15 a first protocol adapted to provide an assigned network address to a mobile terminal for a communications session initially through a particular radio access node within whose coverage area the mobile terminal is located and to broadcast the assigned network address and the network address of the particular radio access node to the plurality of packet routers so as to cause each packet router to create a new next-hop forwarding entry for the mobile terminal, the new next-hop forwarding entry for the mobile terminal corresponding with the next-hop forwarding entry for the particular radio access node;

25 a second protocol adapted to update the next-hop forwarding entries for the mobile terminal for a subset of the packet routers when the mobile terminal moves from the coverage area of the particular radio access node to the coverage area of a subsequent radio access node by causing each packet router in the subset of packet routers to change the next-hop forwarding entry for the mobile terminal to correspond with the next-hop forwarding entry for the subsequent radio access node;

5 a third protocol adapted to define said subset of the packet routers for each {particular radio access node, subsequent radio access node} pair such that only the subset of packet routers are required to update their next-hop forwarding entries for a mobile terminal handoff from the particular radio access node to the subsequent radio access node.

2. A system according to claim 1 further comprising an address server located within the radio access network;

10 wherein the first protocol is adapted to obtain the assigned network address for the mobile terminal from the address server.

3. A system according to claim 2 wherein the address server is an extended dynamic host configuration protocol (DHCP) server.

15 4. A system according to claim 2 wherein the first protocol comprises:

the mobile terminal establishing a wireless communications link with the particular radio access node within whose coverage area the mobile terminal is located;

20 the mobile terminal sending a first message to the particular radio access node within whose coverage area the mobile terminal is located, the first message requesting said assigned network address;

25 the particular radio access node receiving the first message and sending a second message to the address server requesting said assigned network address;

the address server responding to the particular radio access node with a third message comprising said assigned network address for the mobile terminal;

the particular radio access node forwarding the third message to the mobile terminal and then broadcasting a fourth message to the plurality of packet routers in the radio access network, the fourth message comprising the network address for the particular radio access node and the assigned network address for the mobile terminal;

each of the plurality of packet routers adding a new next-hop forwarding entry for the mobile terminal corresponding to the next-hop forwarding entry for the particular radio access node within whose coverage area the mobile terminal is located.

5. A system according to claim 1 wherein the third protocol is adapted to include in the subset only those packet routers having different next-hop forwarding entries for the particular and subsequent radio access nodes.

6. A system according to claim 5 further comprising an address server located within the radio access network;

wherein the third protocol adapted to define said subset of the packet routers for each {particular radio access node, subsequent radio access node} pair comprises:

the particular radio access node broadcasting a first message to the subsequent radio access node;

the subsequent radio access node in response to the first message sending a second message to the address server identifying the particular radio access node and the subsequent radio access node;

the address server assigning a single multicast address to represent said subset of packet routers and sending the multicast address in a third message to the subsequent radio access node;

5 the subsequent radio access node sending a fourth message to the particular radio access node containing the multicast address assigned to said subset of packet routers;

10 the particular radio access node broadcasting a fifth message to each of said plurality of packet routers, the fifth message comprising the network address of the particular radio access node, the network address of the subsequent radio access node and the multicast address assigned to said subset of packet routers;

15 each of said plurality of packet routers comparing the next-hop forwarding entry for the particular radio access node to the next-hop forwarding entry for the subsequent radio access node and in the event that the next-hop forwarding entries are different, issuing a request message to join the subset of packet routers to which the multicast address is 20 assigned.

7. A system according to claim 5 further comprising an address server located within the radio access network;

25 wherein the third protocol adapted to define said subset of the packet routers for each particular radio access node, subsequent radio access node pair comprises:

the particular radio access node sending a first message to the subsequent radio access node;

the subsequent radio access node in response to the first message sending a second message to the address server

identifying the particular radio access node and the subsequent radio access node;

the address server assigning a single multicast address to represent said subset of packet routers and sending the multicast address in a third message to the subsequent radio access node;

the subsequent radio access node sending a fourth message to the particular radio access node, the fourth message comprising the multicast address assigned to said subset of packet routers and a virtual handoff mobile address;

packet routers and a virtual handoff mobile address;

the particular radio access node broadcasting a fifth message to each of said plurality of packet routers, the fifth message comprising the network address of the particular radio access node and the virtual handoff mobile address;

each of said plurality of packet routers receiving the fifth message and adding a first next-hop forwarding entry for the virtual handoff mobile address, the first next-hop forwarding entry for the virtual handoff mobile address corresponding to the next-hop forwarding entry for the particular radio access node;

the particular radio access node sending a sixth message to the subsequent radio access node, the sixth message triggering the subsequent radio access node to broadcast a seventh message to each of said plurality of packet routers, the seventh message comprising the virtual handoff mobile address, the network address of the subsequent radio access node and the multicast address assigned to said subset of packet routers;

each of said plurality of packet routers computing a second next-hop forwarding entry for the virtual handoff mobile address;

each of said plurality of packet routers comparing
5 the second next-hop forwarding entry for the virtual handoff mobile address to the first next-hop forwarding entry for the virtual handoff mobile address and in the event that the next-hop forwarding entries are different, issuing a request message to join the subset of packet routers to which the multicast
10 address is assigned;

the particular radio access node broadcasting an eighth message the said plurality of packet routers so as to cause each packet router to remove the next-hop forwarding entry for the virtual handoff mobile address.

15 8. A system according to claim 1 wherein the first protocol pre-allocates a set of addresses to each radio access node and sets up routes for these addresses in the routers before the addresses are actually assigned to mobile terminals.

Pre-allocation of addresses is achieved by either
20 configuring address prefixes based on network hierarchy or broadcasting to all the routers the association between a RN and a set of allocated addresses as in the first protocol. Both methods de-couples address allocation from mobile terminal registration, therefore, reduce the time required for mobile
25 registration.

9. A system according to claim 1 wherein the second protocol comprises:

the particular radio access node sending a first message to the mobile terminal indicating that a wireless

communications link to the subsequent radio access node should be established;

the mobile terminal receiving the first message and sending a second message to the subsequent radio access node in 5 order to establish a wireless communications link to the subsequent radio access node, the second message identifying the mobile terminal and the particular radio access node whose coverage area the mobile terminal is leaving;

the subsequent radio access node receiving the second 10 message and sending a third message to said subset of packet routers, the third message comprising the network address of the subsequent radio access node and the network address of the mobile terminal;

each packet router in said subset of packet routers 15 receiving the third message and changing the next-hop forwarding entry for the mobile terminal to correspond to the next-hop forwarding entry for the subsequent radio access node.

10. A system according to claim 1 wherein the network addresses are Internet Protocol (IP) addresses.

20 11. A system according to claim 1 wherein the data packets are Internet Protocol (IP) packets.

12. A system according to claim 11 wherein adapted for use with IP version 4 or IP version 6.

13. A method for forwarding data packets to a mobile 25 terminal within a radio access network comprising a plurality of packet routers and a plurality of radio access nodes each having a respective network address, the method comprising:

providing each packet router with a respective next-hop forwarding table populated with next-hop forwarding entries for each of the plurality of radio access nodes;

providing an assigned network address to a mobile
5 terminal for a communications session initially through a particular radio access node within whose coverage area the mobile terminal is located;

broadcasting the assigned network address and the network address of the particular radio access node to the
10 plurality of packet routers so as to cause each packet router to create a new next-hop forwarding entry for the mobile terminal, the new next-hop forwarding entry for the mobile terminal corresponding with the next-hop forwarding entry for the particular radio access node;

15 updating the next-hop forwarding tables of a subset of the plurality of packet routers when the mobile terminal moves from the coverage area of the particular radio access node to the coverage area of a subsequent radio access node by causing each packet router in the subset of packet routers to
20 change the next-hop forwarding entry for the mobile terminal to correspond to the next-hop forwarding entry for the subsequent radio access node.

14. A method according to claim 13 further comprising for each {particular radio access node, subsequent radio access node} pair, defining the subset of packet routers whose next-hop forwarding tables need to be updated when the mobile terminal moves from the coverage area of the particular radio access node to the coverage area of the subsequent radio access node such that only the subset of packet routers are required
30 to update their next-hop forwarding tables.

15. A method according to claim 14 further comprising each router updating its membership in the subset for a {particular radio access node, subsequent radio access node} pair when the next-hop forwarding entry for either or both of 5 the particular radio access node and the subsequent radio access node changes.

16. A method according to claim 13 further comprising radio access nodes learning a neighboring relationship with other radio access nodes in terms of common coverage areas.

10 17. A method according to claim 13 wherein the data packets are Internet Protocol (IP) packets.

18. A method according to claim 13 wherein the network addresses are Internet Protocol (IP) addresses.

19. A packet router comprising:

15 a next-hop forwarding table populated with a next-hop forwarding entry for each of a plurality of mobile terminals and radio access nodes;

20 20 a next-hop forwarding table populated with a next-hop forwarding entry for each of a plurality of mobile terminals and radio access nodes;

an input adapted to receive a message identifying a network address for a mobile terminal and a network address for 20 a particular radio access node within whose coverage area the mobile terminal is located;

a message processor adapted to process said message by:

25 in the event no next-hop forwarding entry exists for the mobile terminal, adding a new next-hop forwarding entry to the next-hop forwarding table for the mobile terminal, the new next-hop forwarding entry corresponding

to the next-hop forwarding entry already in the table for the particular radio access node;

5 and in the event a next-hop forwarding entry exists for the mobile terminal, changing the next-hop forwarding entry for the mobile terminal to correspond to the next-hop forwarding entry already in the table for the particular radio access node;

wherein a data packet to be routed contains a destination network address of a mobile terminal to which the
10 packet is to be routed, and the packet router forwards the packet according to the next-hop forwarding entry for the destination network address contained in the packet.

20. A packet router according to claim 19 wherein the next-hop forwarding table is organized as an array indexed with
15 network addresses for each of the plurality of mobile terminals and radio access nodes.

21. A packet router according to claim 19 wherein the next-hop forwarding table is organized as an array and associates a network address for each of the plurality of
20 mobile terminals and radio access nodes with a network address for a next-hop forwarding device.

22. A packet router according to claim 19 further comprising host route summarization and de-summarization algorithms adapted to compress the routing table.

25 23. A packet router according to claim 22 wherein host route summarization algorithm summarizes common forwarding paths into a single path identified by a common address prefix of destination network addresses.

24. A packet router according to claim 22 wherein the de-summarization algorithm de-summarizes a common forwarding path identified by a common address prefix into separate paths due to a mobile terminals forwarding path departing from the common path.

25. A packet router according to claim 19 adapted to route Internet Protocol (IP) packets.

26. A packet router according to claim 25 wherein the network addresses are Internet Protocol (IP) addresses.

10 27. A radio access node adapted to provide wireless access service to a mobile terminal within a radio access network comprising a plurality of packet routers and an address server, the radio access node being adapted to:

15 receive a first message from the mobile terminal requesting a network address for the mobile terminal from the address server;

process said first message by sending a second message to the address server requesting a network address to be assigned to the mobile terminal;

20 receive a second message from the address server comprising the assigned network address;

process said second message by sending a third message to the mobile terminal comprising the assigned network address from the address server;

25 broadcast a fourth message to the plurality of packet routers, the fourth message comprising the network address of the radio access node and the assigned network address for the mobile terminal.

28. A radio access node adapted to provide wireless access service to a mobile terminal within a radio access network, the radio access network comprising a plurality of packet routers and a plurality of radio access nodes each having a respective coverage area and each capable of establishing a wireless communications link with mobile terminals within the respective coverage area, each packet router and each radio access node having a respective network address, the radio access network further comprising an address server for assigning a multicast address to represent a subset of the packet routers that needs to be updated when the mobile terminal moves from the coverage area of the particular radio access node to the coverage area of a subsequent radio access node, the radio access node comprising:

15 a message processor adapted to send a first message to the subsequent radio access node;

an input adapted to receive a second message from the subsequent radio access node comprising the multicast address assigned by the address server;

20 the message processor further adapted to broadcast a third message to the plurality of packet routers, the third message comprising the network address of the particular radio access node, the network address of the subsequent radio access node and the assigned multicast address for said subset of 25 packet routers.

29. A radio access node adapted to provide wireless access service to a mobile terminal within a radio access network, the radio access network comprising a plurality of packet routers and a plurality of radio access nodes each having a respective coverage area and each capable of establishing a wireless communications link with mobile

terminals within the respective coverage area, each packet router and each radio access node having a respective network address, the radio access network further comprising an address server for assigning a multicast address to represent a subset 5 of the packet routers that needs to be updated when the mobile terminal moves from the coverage area of the particular radio access node to the coverage area of a subsequent radio access node, the radio access node comprising:

10 a message processor adapted to implement a third protocol wherein the third protocol defines said subset of packet routers for the particular radio access node, subsequent radio access node pair.

30. A radio access node according to claim 29 wherein the address server is an extended dynamic host configuration 15 protocol (DHCP) server.

31. A radio access node according to claim 29 wherein the network addresses are Internet Protocol (IP) addresses.

32. A method of providing micro-mobility support to a radio access network wherein only a reduced number of routers 20 update their next-hop forwarding tables when a mobile terminal performs a handoff.

33. A method according to claim 32 wherein the reduced number of routers comprises any routers having different next-hop forwarding entries for the particular radio access node and 25 the subsequent radio access node.

34. A system according to claim 1 wherein the first, second and third protocols together provide a protocol suite adapted to function as a mobile routing protocol for updating a mobile terminal's reachability in an overlay network that

comprises mobility agents connected by IP tunnels over network routers.

35. A system according to claim 34 wherein the protocol suite runs in the mobility agents.

5 36. A mobility agent adapted to be connected with other mobility agents using IP tunnels, the mobility agent being adopted to provide a protocol suite comprising:

a first protocol adapted to provide an assigned network address to a mobile terminal for a communications session initially through a particular radio access node within whose coverage area the mobile terminal is located and to broadcast the assigned network address and the network address of the particular radio access node to a plurality of packet routers so as to cause each packet router to create a new next-hop forwarding entry for the mobile terminal, the new next-hop forwarding entry for the mobile terminal corresponding with the next-hop forwarding entry for the particular radio access node;

a second protocol adapted to update the next-hop forwarding entries for the mobile terminal for a subset of the packet routers when the mobile terminal moves from the coverage area of the particular radio access node to the coverage area of a subsequent radio access node by causing each packet router in the subset of packet routers to change the next-hop forwarding entry for the mobile terminal to correspond with the next-hop forwarding entry for the subsequent radio access node;

a third protocol adapted to define said subset of the packet routers for each {particular radio access node, subsequent radio access node} pair such that only the subset of

packet routers are required to update their next-hop forwarding entries for a mobile terminal handoff from the particular radio access node to the subsequent radio access node.